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TWO DIMENSIONS OF PRODUCTIVITY

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About twenty years ago, at a time when some men occupying prominent positions in the field of economics were emphasizing the resemblances of the instruments of production, with a view to formulating simple and comprehensive principles, one teacher was saying to his students: "Give careful attention to the differences in the economic characteristics of the instruments of production. In these differences we may find some of the most significant conditions of our economic life." The facts and theories which are presented in this paper are the result of taking this advice.

Much has been heard in recent years about efficiency and the efficiency movement in the industries. It is a matter of no small significance that attention is being turned to that long-neglected branch of our science, the economics of production.

With the increasing cost of living, economy in production is becoming as important a branch of our subject as justice in distribution. The latter has not received too much attention but has received much better consideration than the field of production. The economic problems in agricultural production center about the questions of what to produce; the proper proportions of the factors of production, commonly discussed under the heading of intensity of culture; the size of farms; and the question of the grades of the factors which should be combined. The last problem implies variations in the usefulness of the instruments of production. It appears that these variations have at least two dimensions which are as different as length and breadth. These differences may be designated as differences in capacity and differences in efficiency. It is the purpose of this paper to discuss the significance of capacity and efficiency as they are related to productivity and the problem of land ownership on the part of farmers. Both of these terms are often used in the same sense as productivity, whereas they represent the two conditions of productivity.

Capacity has been defined as power to receive, absorb, take into, or associate with. The word capacity has in recent years been popularly used to indicate the output of a mill or factory. In this paper the original, and still the dictionary, meaning of capac-

ity will be adhered to. In this sense capacity refers to "input," not to output. It has been recognized since the days of Ricardo that land varies with respect to the amount of labor and capital which can be invested per acre with optimum results, that is, land varies in capacity. Cows vary greatly in the amount of feed which they can consume with optimum results when fed with the same care and by the same man, hence cows vary in capacity. The same thing is found true of every specific class of instruments of production from milk pails to threshing machines. Variation in capacity exists likewise in the human factor. There is a very wide range of differences in men with respect to the amounts of land, labor, and capital they can operate. High capacity is not always a desirable quality. For example, certain land requires much more power to plow and more work with the pulverizer and harrow to put it in condition for planting seeds, yet does not produce extra large crops per acre. The labor of milking some cows is twice as great as that required in milking others, and they do not necessarily produce any more milk. Capacity, or the power to absorb the other factors, implies nothing as to usefulness of a factor unless taken in conjunction with efficiency.

Efficiency is defined as a ratio between the energy put in and the results secured. The efficiency of a factor of production is measured in terms of the value of the product per unit of the other factors (of given grades of efficiency) when associated in the most profitable proportions. To illustrate, two pieces of land may yield widely different results per hour of man and horse labor expended upon them by the same man. Two cows may vary widely in the amount of butter fat they yield per pound of feed consumed when the two cows are fed by the same man upon the same feeds.

The relation of capacity, efficiency, and productivity are easily understood. The productivity of a physical unit of an instrument of production, as an acre of land or a cow, is the resultant of capacity and efficiency. The product divided by the capacity equals the efficiency. In other words, capacity relates to "input"; efficiency to "output" per unit of "input"; and productivity relates to the total product per acre of land, per cow, or per man. The calculation of efficiency may be made in terms of physical product or in terms of the value of the product. In analyzing the productivity of cows and other movable instruments of production, physical productivity is often the better basis of comparison because of differences in values at different locations. In

the case of immovable instruments of production the value of the product is the more satisfactory basis of comparison.

Ricardo recognized two dimensions of productivity as they relate to land, but he apparently did not see that they applied also to the other factors of production. In their attempts to simplify a subject which by nature is complex, some writers have desired to reduce all differences to difference in capacity, in order to assume that physical units of a factor, say men, are quite *interchangeable*. But as a matter of fact differences in efficiency cannot be commuted into differences in capacity.

A few facts may help to make clear the ideas in mind. In recent years a great deal of first-hand study has been made of the conditions of productivity in agriculture. The census method and the accounting method have been largely used in this work. In Table I is found the results of a careful census of the farmers centering about Dallas, Barron County, Wisconsin. There were fifty-one farmers in the community. The returns which these farmers secured per dollar of annual outlay varied from 76 cents to \$3.05. In this calculation the annual outlay included all operating expenses, including depreciation and interest. A glance at the second column of figures in Table I shows a variation from \$1734 to \$293 in the annual outlay with which these farmers associated themselves. The former are termed variations in efficiency; the latter are designated differences in capacity. (Though the writer would recognize that perfect adjustments may not exist with regard to the amount of land, labor, and equipment associated with some of the men, yet these men are probably striving for the optimum.) The variations in total product per man range from \$3644 to \$686. The farmers, as the residual claimants, received payments for their efforts varying from \$1961 to minus \$338. It will be noted that, so far as the figures in this table go, there is no definite relation between a man's capacity as measured by his outlay and his efficiency as measured by product per unit of outlay. A man with high efficiency may have low capacity and the man with high capacity may have any degree of efficiency. These facts are brought forward to illustrate the well-known fact of variations in the ability of men and to note that at least two measuring sticks are needed if we hope accurately to measure man's ability.

Table II illustrates some of the differences which exist in one class of instruments of production, namely, cows. This table

shows the best ten and the worst ten of 398 cows entered in the Wisconsin Dairy Cow Competition during the two years 1909-1911, each cow being in the contest one year. It will be noted that the difference in value of product per dollar's worth of feed consumed by the best ten cows varied from \$2.71 to \$2.19 and that the range for the least efficient ten cows was from \$1.25 to 92 cents. The total range was from \$2.71 to 92 cents, the average result of the best ten was \$2.38 and that of the least efficient ten was \$1.12. In Table II a common or standard price level was used in calculating the cost of the feed and the value of the product. It remains, however, to be explained that these cows were not all under the same management. The differences in product per unit of feed are due, therefore, to differences in the efficiency of men as well as to differences in the efficiency of cows. The cows in one herd in the same barn, receiving the same feed, care, and management, must be compared if cow efficiencies are to be isolated. In Table III this condition is provided. Twenty-six cows, all pure-breds and supposed to be very high class, show a range in efficiency from \$2.46 to \$1.44. The surplus product over feed cost being more than three times as great from the most efficient as from the least efficient. The range in capacity was from \$99.83 to \$82.69. It is possible to pile up unlimited quantities of facts which show similar variations in the other instruments of production.

The fact of differences in efficiency and capacity granted, are they significant from the standpoint of production? From the point of view of the effective management of farms the significance of this analysis of the grades of the factors of production lies in its relation to the problem of *right choice* of the instruments of production which are to be combined under a given management.

If differences in market valuations correspond to each man's estimate of the variations in the usefulness of these instruments, the problem of choice would be solved, but unfortunately this is not true. The individual valuations of given instruments of production have a wide range above and below the market valuations.

It is this discrepancy between individual and market valuations or "value in use and value in exchange" which prohibits taking the position that one dollar's worth of agricultural land, labor, or equipment is as useful to the farmer as any other dollar's worth, that market prices eliminate the necessity of careful selection of the grades of the factors of production, and which makes it neces-

sary for each farmer to use great care in the choice of the productive agents with which he associates himself.

Does it make any difference which grades of capacity are chosen? Only in the same sense that the mason finds use for stones of different sizes in building a wall, each occupying space according to its size, where there are spaces of varying dimensions to be filled. To take specific cases, a low capacity cow may best serve the purpose of a city man wanting a small amount of milk for his own family. A boy of half capacity may just fill out the need for additional labor on a given farm. Aside from this, choice is not based upon capacity but upon the efficiency of the factors.

The surplus product of cow No. 1 is much greater when on the farm of Mr. A. than when on the farm of Mr. B. Because of this Mr. A. can pay more for this cow than Mr. B. can pay without suffering a relative loss. Furthermore, the surplus due to Mr. A's superior efficiency is greater when he keeps cows of superior efficiency than when he keeps cows of low efficiency. The result of competition tends therefore to put the most efficient cows into the hands of the most efficient dairymen, and the marginal cows into the hands of the marginal dairymen. This seems to be true of all the factors of production and tends to combine these factors on the basis of their grades of efficiency. If a given farmer associates himself with an efficiency grade other than that which corresponds to his own grade of efficiency, whether it be higher or lower, his profits will fall short of the possible maximum.

How does this affect total productivity? Total productivity of society is greatly increased by the combination of the factors which throws the most efficient factors together. The productivity of the inefficient is minimized, it is true, but the productivity of the most efficient is at the maximum, and the total product, it is believed, is greater than any other combination would yield. True social economy calls for this combination, and it is these facts of variation in efficiency which give hope that competition may gradually lift the average of efficiency by the elimination of the marginal and the multiplication of the better and the best. So long as this process is in operation poorhouses will be needed, but is it not cheaper to provide for the inefficient in this way than to have them match their inefficiency with land and equipments which have high potential productivity?

Variations in efficiency and capacity have an important relation

to the problems of the distribution of wealth, with especial reference to the ownership of land. It is the wide range in the efficiency and the capacity of farmers that makes possible the saving of the funds essential to the climbing of the agricultural ladder. Assuming the acceptance of the theory of the relation of prices of agricultural products and marginal costs, it follows that every man possessing efficiency superior to that of the marginal farmer may save from the surplus and rise to a higher rung on the agricultural ladder. It would seem also that the man of high capacity may save more than his competitor of equal efficiency who possesses lower capacity, the assumption here involved being that the man of high capacity may have the same standard of living as his competitors. The emphasis is upon the opportunity to save, not upon the use made of this opportunity. This all points to the need of keeping obstructions off of the agricultural ladder, so that there will be an inducement to save with a view to buying land.

It is because of the significant relation of these variations in the usefulness of men and capital goods to the problems of economy in production and to a socially desirable distribution of agricultural wealth, that I have asked your attention to this subject. For the sake of brevity many arbitrary statements have been made which I might rather have put in the form of questions. The question of terminology is entirely superficial, yet I shall be pleased to have suggestions on the choice of terms as well as upon the development of principles.

TABLE I
VARIATIONS IN EFFICIENCY AND CAPACITY OF FIFTY-ONE FARMERS
LIVING NEAR DALLAS, BARRON Co., WISCONSIN

EFFICIENCY		CAPACITY		PRODUCTIVITY			
Rank	Product per Dollar of Outlay	Rank	Annual Outlay	Rank	Total Value of Product	Rank	Residuum for Farmer's Effort
1	\$3.05	48	\$ 421	37	\$1285	18	\$ 864
2	2.84	33	932	8	2649	4	1717
3	2.63	47	434	41	1143	22	709
4	2.48	51	293	48	727	34	434
5	2.40	49	333	46	799	32	466
6	2.16	4	1683	1	3644	1	1961
7	2.13	16	1334	7	2844	6	1510
8	2.12	39	775	26	1646	16	871
9	2.11	29	1026	16	2165	12	1139
10	2.10	13	1379	6	2895	5	1516
11	2.10	32	961	18	2018	13	1057
12	2.09	1	1734	2	3619	2	1885
13	2.07	5	1675	3	3473	3	1798
14	2.05	21	1203	10	2472	8	1269
15	2.03	30	983	19	2000	10	1017
16	1.90	50	395	49	749	41	354
17	1.88	15	1344	9	2533	11	1189
18	1.86	6	1618	4	3016	7	1398
19	1.84	42	739	33	1361	26	622
20	1.83	37	881	27	1610	21	729
21	1.82	18	1266	13	2307	14	1041
22	1.75	24	1124	20	1963	19	839
23	1.72	3	1695	5	2909	9	1214
24	1.71	17	1278	15	2192	15	914
25	1.71	45	563	45	962	36	399
26	1.70	35	894	29	1522	25	628
27	1.64	44	620	43	1015	38	395
28	1.62	12	1392	14	2259	17	867
29	1.60	43	715	40	1146	35	431
30	1.60	23	1165	22	1868	23	703
31	1.59	36	885	32	1410	29	525
32	1.56	46	440	51	686	44	246
33	1.52	40	764	39	1162	37	398
34	1.52	22	1173	25	1778	27	605
35	1.48	7	1595	11	2358	20	763
36	1.47	27	1090	28	1602	31	512
37	1.47	31	978	31	1435	33	457
38	1.38	14	1358	23	1878	30	520
39	1.37	2	1703	12	2339	24	636
40	1.36	8	1595	17	2165	28	570
41	1.29	28	1018	36	1309	42	291
42	1.26	9	1505	21	1898	39	393
43	1.24	10	1492	24	1853	40	361
44	1.24	20	1211	30	1496	43	285
45	1.20	25	1103	35	1320	45	217
46	1.11	26	1095	38	1219	46	124
47	1.08	34	932	44	1009	48	77
48	1.07	19	1263	34	1348	47	85
49	1.02	41	742	47	759	49	17
50	.88	38	804	50	713	50	-91
51	.77	11	1469	42	1131	51	-338
Average	\$1.66		\$1079.8		\$1797.2		\$717.4

TABLE II
EFFICIENCY, CAPACITY, AND PRODUCTIVITY OF THE BEST TEN AND THE POOREST
TEN OF THE 398 COWS IN THE WISCONSIN DAIRY COW COMPETITION, 1909-1911
(FEED AND PRODUCT VALUES STANDARDIZED)

The Most Efficient Ten Cows							
EFFICIENCY		CAPACITY		PRODUCTIVITY			
Rank	Product per Unit of Feed	Rank	Value of Feed Consumed	Rank	Value of Product per Cow	Rank	Value of Product minus Cost of Feed
1	\$2.71	8	\$ 75.32	5	\$204.11	4	\$128.79
2	2.26	5	88.56	6	200.33	7	111.77
3	2.60	10	64.62	10	167.94	10	103.32
4	2.49	9	72.60	9	180.60	8	108.00
5	2.46	2	99.83	2	246.10	2	146.27
6	2.36	7	78.24	8	184.94	9	106.70
7	2.34	6	83.88	7	196.06	6	112.18
8	2.31	3	99.20	3	229.55	3	130.35
9	2.28	4	94.06	4	214.87	5	120.81
10	2.19	1	129.40	1	283.84	1	154.44
Average of best ten	\$2.38		\$88.57		\$210.83		\$122.26

The Least Efficient Ten Cows							
1	\$1.25	6	\$ 77.17	3	\$ 96.69	1	\$19.52
2	1.20	2	96.55	2	115.75	2	19.20
3	1.18	10	67.28	8	79.10	5	11.82
4	1.18	9	74.82	6	88.06	4	13.24
5	1.13	1	103.69	1	117.45	3	13.76
6	1.11	4	82.47	4	91.72	6	9.25
7	1.10	7	75.22	7	82.66	7	7.44
8	1.06	3	84.85	5	90.26	8	5.41
9	.98	8	76.38	9	75.14	9	-1.24
10	.92	5	80.26	10	74.16	10	-6.10
Average of poorest ten	\$1.11		\$81.87		\$91.10		\$9.23

TABLE III
 VARIATIONS IN EFFICIENCY AND CAPACITY OF 26 REGISTERED COWS OF THE
 SAME BREED UNDER THE SAME MANAGEMENT

EFFICIENCY		CAPACITY		PRODUCTIVITY			
Rank	Product per Unit of Feed	Rank	Value of Feed Consumed	Rank	Value of Product per Cow	Rank	Value of Product minus Cost of Feed
1	\$2.46	1	\$99.83	1	\$246.10	1	\$146.27
2	2.40	16	86.42	5	207.76	4	121.34
3	2.38	7	91.05	3	216.52	3	125.47
4	2.34	5	94.05	2	220.01	2	125.96
5	2.28	4	94.06	4	214.87	5	120.81
6	2.13	18	86.06	6	183.53	6	97.47
7	2.09	20	84.20	10	176.39	7	92.19
8	2.06	14	86.70	8	178.56	8	91.86
9	2.05	13	86.75	9	178.11	9	91.36
10	1.93	15	86.59	13	166.70	12	80.11
11	1.91	11	88.52	12	169.20	11	80.68
12	1.91	6	94.01	7	179.25	10	85.24
13	1.82	17	86.23	15	157.20	14	70.97
14	1.76	3	98.93	11	174.64	13	75.71
15	1.74	26	82.69	20	143.61	18	60.92
16	1.73	25	82.94	22	143.18	10	60.24
17	1.72	12	87.03	18	150.02	16	62.99
18	1.72	9	89.07	16	153.51	15	64.44
19	1.72	21	83.52	21	143.61	20	60.09
20	1.69	23	83.10	23	140.46	22	57.36
21	1.69	9	89.16	17	150.68	17	61.52
22	1.65	24	83.01	24	136.60	24	53.59
23	1.63	8	89.32	19	145.41	23	56.09
24	1.60	22	82.22	25	131.35	25	49.13
25	1.58	2	99.74	14	157.28	21	57.54
26	1.44	19	84.77	26	122.22	26	37.45
Average	\$1.91		\$88.46		\$168.72		\$80.26